Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas

Quarterly Technical Progress Report
January 1 – March 31, 2005

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Disclaimer

Abstract

This document summarizes progress on Cooperative Agreement DE-FC26-03NT41987, "Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas," during the time-period January 1, 2005 through March 31, 2005. The objective of this project is to demonstrate the ability of various activated carbon sorbents to remove mercury from coal-combustion flue gas across full-scale units configured with small ESPs. The project is funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Southern Company, and Georgia Power are project co-funders. URS Group is the prime contractor.

Various carbon-based sorbents were injected upstream of low SCA ESP systems at Georgia Power's Plant Yates Unit 1 and Unit 2. Both Unit 1 and Unit 2 fire a low sulfur bituminous coal. Unit 1 is equipped with a JBR wet FGD system downstream of the ESP for SO_2 control. Unit 2 is not equipped with downstream SO_2 controls; however, a dual flue gas conditioning system is used to enhance ESP performance.

Short-term parametric tests were conducted on Units 1 and 2 to evaluate the performance of activated carbon sorbents. In addition, the effects of the dual flue gas conditioning system on mercury removal performance were evaluated as part of the short-term parametric test on Unit 2. Based on the results of the parametric tests, a single sorbent was selected for longer-term full-scale tests on Unit 1 to observe long-term performance of the sorbent, and its effects on ESP and JBR FGD system operations and combustion byproduct properties. The results of this study provide data required for assessing the performance, long-term operational impacts, and estimating the costs of full-scale sorbent injection processes for flue gas mercury removal.

This is the sixth full reporting period for the subject Cooperative Agreement. During this period, an additional set of parametric carbon injection tests was executed at Plant Yates Unit 1. Data reduction and analysis of collected samples was performed for these parametric tests. Further analysis was conducted on data collected during the continuous long-term injection test in the fifth reporting period.

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List of Acronyms

acfm	Actual cubic feet per minute
ACI	Activated Carbon Injection
APCD	Air pollution control device
APH	Air preheater
ASTM	American Society for Testing and Materials
CEM	Continuous emissions monitor
CO_2	Carbon dioxide
CT-121	Chyodia Thoroughbred - 121
CVAA	Cold vapor atomic absorption
ê P	“Delta P”, Pressure drop or pressure difference
DOE	Department of Energy
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESP	Electrostatic precipitator
FGD	Flue gas desulfurization
FGD™	Norit America’s Darco FGD™ activated carbon
HCl	Hydrochloric acid
Hg	Mercury
HOK	RWE Rhinebraun’s Super HOK activated carbon
IGS	Inertial gas separation
JBR	Jet bubbling reactor
LOI	Loss on ignition
MW	Megawatt
NETL	National Energy Technology Laboratory
NH Carbon	Ningxia Huahui Activated Carbon
NH_3	Ammonia
NIST	National Institute of Standards and Technology
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
OH	Ontario Hydro
PSD	Particle size distribution
QA/QC	Quality assurance/quality control
SCA	Specific collection area
SCEM	Semi Continuous Emission Monitor
SO_2	Sulfur dioxide
SO_3	Sulfur trioxide
U.S.	United States

1.0 Executive Summary

This document summarizes progress on Cooperative Agreement DE-FC26-03NT41987, "Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas," during the time-period January 1, 2004 through March 31, 2005. The objective of this project is to demonstrate the ability of various activated carbon sorbents to remove mercury from coal-combustion flue gas across full-scale units configured with small ESPs. The project is funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Southern Company, and Georgia Power are project co-funders. URS Group is the prime contractor.

Several carbon-based sorbent materials were injected upstream of low-SCA ESPs at Georgia Power's Plant Yates Unit 1 and Unit 2. Both Unit 1 and Unit 2 fire a low sulfur bituminous coal. Unit 1 is equipped with a cold-side ESP upstream of a JBR wet FGD system for SO_2 control. Unit 2 is not equipped with downstream SO_2 controls; however, a dual flue gas conditioning system is used to enhance ESP performance.

During this reporting period, analysis continued on the data collected during the long-term injection test on Unit 1. The carbon selected for the long-term injection test was RWE Rheinbraun's Super HOK carbon. The majority of the test was conducted at carbon injection rates between 4 and 10 lb/Macf. Mercury removal across the ESP ranged from 50 to 91% over the test period, with the majority of the data concentrated between 60 and 85%. The mercury removal across the ESP/JBR scrubber system ranged from 70 to 94%. In contrast, baseline (no injection) mercury removals were 50% across the ESP and 80% across the system.

Detailed analyses were conducted to relate the mercury removal performance to the unit load operating condition and to compare results to the original parametric tests. A thorough evaluation of ESP arcing data was conducted. A second set of parametric injection tests was conducted during this reporting period. Alternative sorbents, such as a brominated carbon and ash/carbon mixture were tested. Results from the long-term and parametric tests are currently under review by project team members, so results will be released in a future quarterly report.

2.0 Experimental

2.1 Plant Configuration

Figure 2-1 shows the basic plant configuration, sorbent injection points, and flue gas sample locations for Units 1. Characteristics of the unit are summarized in Table 2-1 and have been described in previous reports.

Table 2-1. Plant Yates Unit 1 and 2 Configurations

	Yates Unit 1	Yates Unit 2
Boiler		
Type	CE Tangential Fired	
Nameplate (MW)	100	
Coal		
Type	Eastern Bituminous	
Sulfur (wt %, dry)	1.0	
Mercury (mg/kg, dry)	0.06-0.14	
Chloride (mg/kg, dry)	150-450	
ESP		
Type	Cold-Side	
ESP Manufacturer	Buell (1968 and 1971 vintage, refurbished in 1997)	
Specific Collection Area (ft^2/1000afcm)	173	144
Plate Spacing (in.)	11	
Plate Height (ft)	30	
Electrical Fields	3	2
Mechanical Fields	4	3
ESP Inlet Temp. (°F)	310	300
ESP Design Flow Rate (ACFM)	490,000	420,000
NO_x Controls	Low NOx Burners	None
SO_2 Controls	Chiyoda CT-121 wet scrubber (JBR)	None
Flue Gas Conditioning	None	Dual NH_3/SO_3

2.2 Experimental Methods

The sorbent injection equipment was described in the first technical report. The mercury measurements for baseline and injection testing were performed with mercury semi-continuous analyzers, which have been described in previous reports. Particulate loading was measured via Method 17 traverses in the duct. During injection testing, Ontario Hydro and Method 17 were conducted.

Solid and liquid samples, such as FGD byproduct slurry, fly ash, and coal, were collected and analyzed for mercury content. Coal samples were digested with ASTM 3684 and analyzed for mercury by CVAA. Ash samples and FGD solid samples were digested by a standard hydrofluoric acid digestion and analyzed for mercury by CVAA. All liquid samples were prepared by EPA Method 7470 and analyzed by CVAA.

2.3 Progress by Task

Progress on the various project tasks are described in the following sections. A summary of progress is provided in Table 2-2.

Table 2-2. Schedule for FY 2004 Milestones for this Test Program

Milestone	Description	Planned Completion	Actual Completion
1	Hazardous substance plan	Q1	Q1
2	Project kickoff meeting	Q1	Q1
3	Site Survey – Units 1 and 2	Q1	Q1
5	Test plan – Units 1 and 2	Q1	Q2
6	Complete sorbent injection system installation for parametric tests – Units 1 and 2	Q2	Q2
7	Complete baseline and parametric tests for sorbent 1 (Darco FGD™ carbon) on Units 1 and 2	Q2	Q2
8	Complete baseline and parametric tests for sorbent 2 (Super HOK carbon) on Unit 1	Q3	Q3
9	Transfer and install ACI silo and feeder system on Unit 1 for long-term tests	Q4	Q4
10	Initiate long-term test on Unit 1	Q4	Q1-FY2005
11	Complete long-term test on Unit 1	Q4	Q1-FY2005
12	Complete data workup for Units 1 and 2	Q2-FY2005	Q2-FY2005
13	Initiate economic analysis	Q2-FY2005	Q2-FY2005

Task 1 – Project Planning

Three different sorbents were evaluated in initial parametric tests on Unit 1 during Spring 2004. A description of each sorbent is provided in Table 2-3. RWE Rheinbraun's Super HOK sorbent was selected for the long-term tests on Unit 1. The sorbent was selected because of its comparable performance and lower cost compared to Norit America's Darco Hg (formerly known as Darco FGD™). Figure 2-2 shows the performance curves for the three carbons tested in Spring 2004. The percent reduction in vapor phase mercury concentration at the ESP outlet is plotted against the sorbent injection rate. For the Darco FGD™ and the Super HOK, mercury reduction reached a plateau of 35-45% at an injection rate between 6 and 9 lb/Mmacf.

Following the long-term injection tests, the project team decided to evaluate additional sorbents in parametric testing on Unit 1. These sorbents were selected for various reasons, including potential lower cost and the potential to overcome the plateau in removal performance seen in the Spring 2004 tests with the Darco Hg and Super HOK. The three new sorbents tested in this additional round of parametric tests were RWE Rheinbraun's coarse grind HOK, Norit's Darco Hg-LH (a brominated carbon, formerly known as Norit E-3), and a sorbent/ash mixture prepared by Southern Company. In addition, Norit's Darco Hg was tested again to compare its performance to the Spring 2004 results and to the sorbent/ash mixture.

The HOK carbon used in these parametric tests had the same composition as the carbon tested during the long-term evaluation in November/December 2004; however, for these tests the HOK carbon had a larger (coarser) particle size. RWE Rheinbraun had experience from other testing that suggested that the coarser HOK might provide nearly as good mercury removal as the finely ground HOK at a lower cost.

Testing of Norit's Darco Hg-LH at other low-Cl coal sites has shown the sorbent to have higher mercury removal than untreated activated carbons. It was desired to see if a brominated carbon would have as good of a relative performance in higher chloride flue gas, like the flue gas at Plant Yates.

The sorbent/ash mixture combines Norit FGD with Plant Miller PRB fly ash in a 50/50 mixture. It is believed that the alkaline nature of the PRB ash (due to high calcium content) may work synergistically with the activated carbon. The 50/50 combination has been tested at Southern Company's Plant Gaston, producing mercury removals close to pure carbon material. An ash/sorbent mixture has a potential cost advantage over pure activated carbon, due to the low cost of the raw ash material.

Table 2-3. Sorbents Selected for Test Program

Carbon Name	Manufacturer	Description	Cost ($/lb)
Darco Hg (formerly Darco FGD™)	Norit Americas	Lignite-derived activated carbon; baseline carbon (19 µm mean particle size)	0.44
Super HOK	RWE Rheinbraun	German lignite-derived activated carbon (23 µm mean particle size)	0.29 [a]
NH Carbon	Ningxia Huahui Activated Carbon Co. LTD (HHAC)	Chinese iodated bituminous-derived activated carbon (24 µm mean particle size)	0.88

a = F.O.B. an east coast port

Table 2-4. Additional Sorbents Selected for Parametric Test Program

Carbon Name	Manufacturer	Description	Cost ($/lb)
HOK-coarse	RWE Rheinbraun	German lignite-derived activated carbon (63 µm mean particle size)	0.265 [a]
Darco Hg-LH	Norit Americas	Brominated, lignite-derived activated carbon; (19 µm mean particle size)	0.65
PRB/Darco Hg		Mixture that is 50/50 PRB ash from Southern Company's Miller Station and Darco Hg sorbent	>~0.23

a = F.O.B. an east coast port
b = Assume $0.44/lb for Darco Hg; $0.0175/lb for PRB ($35/ton); so 50/50 mix is $0.22 +$ 0.0085 = $0.23/lb plus mixing and transportation costs

Task 2 – Unit 1 Testing

The Unit 1 parametric testing with Darco FGD™, Super HOK, and NH carbons has been completed and results have been reported in previous quarterly reports. A long-term performance test began in mid-November 2004 and finished in mid-December 2004. The initial plan had been to perform the long-term test during FY04-Q4. However, several factors resulted in a delay in the initial schedule; these factors were associated with plant operation during ozone attainment season and a Unit 1 outage during October. It was thus determined that the best time to perform the long-term test was November-December, 2004.

Further Unit 1 parametric testing with HOK-coarse, Darco Hg-LH, and PRB/Darco Hg mixture was completed in January 2005. Results are presented in this quarterly report.

Task 3 – Unit 2 Testing

The Unit 2 parametric testing with Darco FGD™ carbon has been completed and results have been reported in previous quarterly reports. .

Task 4 – Data and Economic Analysis

Data analysis of the parametric tests on Units 1 and 2 has been completed and is reported in previous quarterlies. A draft site report has been issued for Unit 2. The economic analysis of sorbent injection was begun.

Task 5 – Waste Analysis and Byproduct Sampling

Samples of fly ash and gypsum byproduct were collected during the long-term ACI test on Unit 1. The collected samples will be shipped to a designated laboratory for testing as part of NETL's Waste and Byproduct Characterization program.

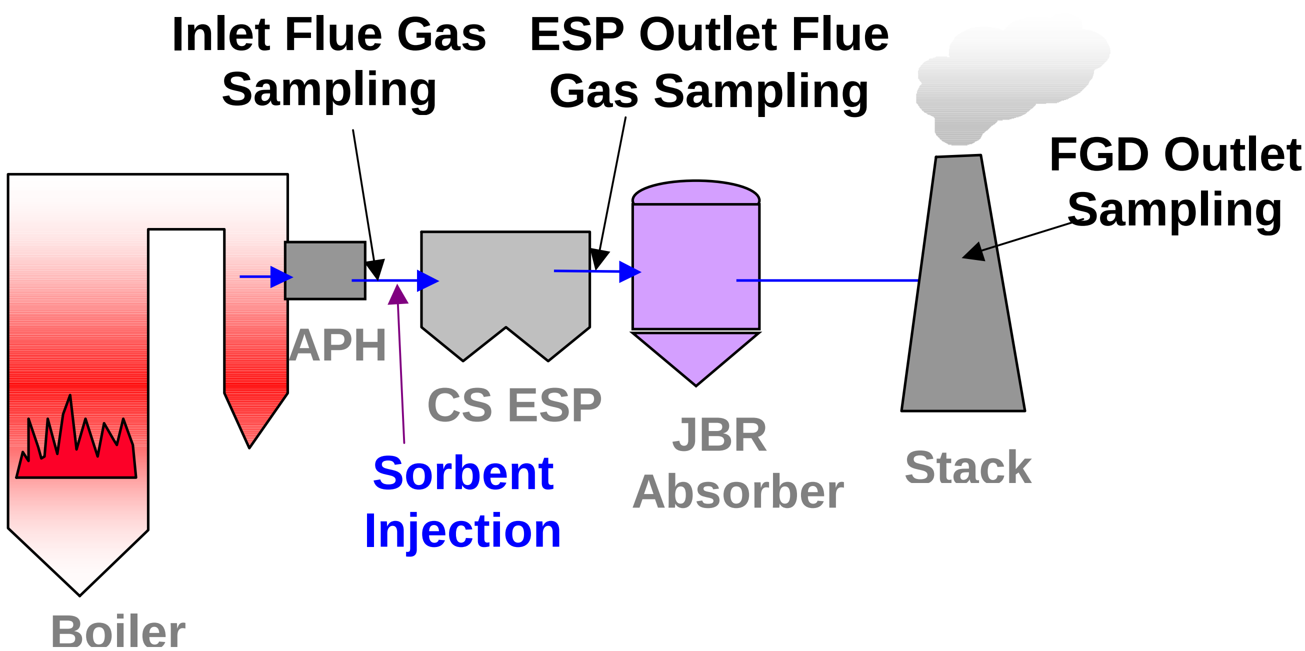

Figure 2-1. Unit 1 Configuration and Flue Gas Sample Locations

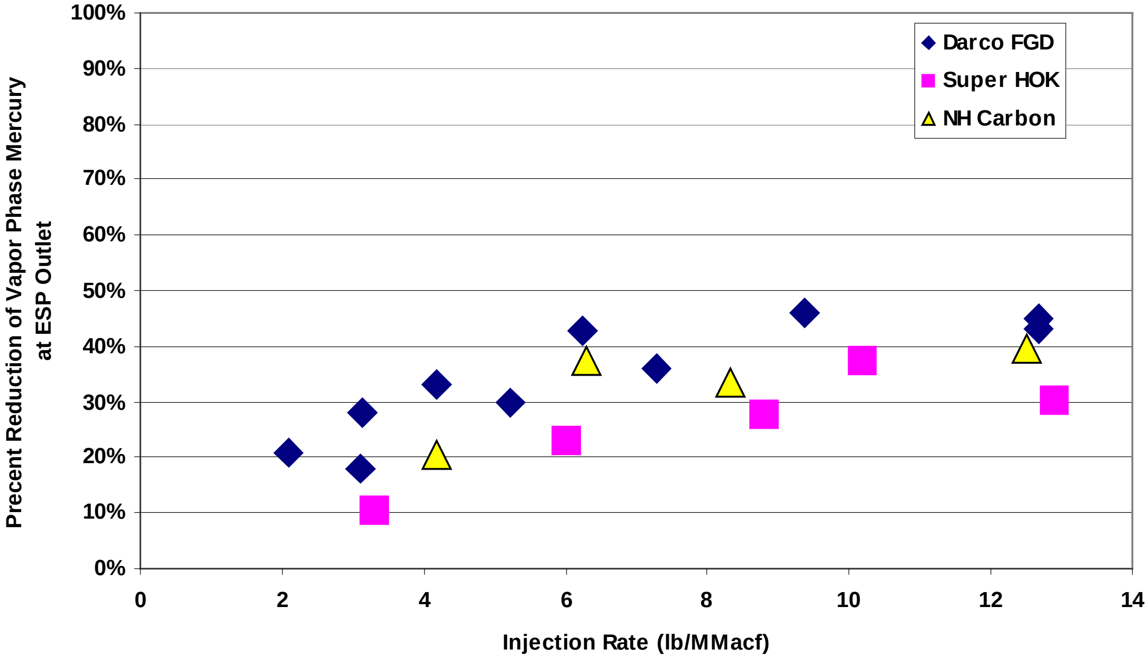

Figure 2-2. Reduction in Vapor Phase Mercury Concentration at ESP Outlet for the Three Sorbents Tested in the Unit 1 Parametric Tests

3.0 Results and Discussion

During this quarter, further data analysis was conducted on the long-term carbon injection test at Yates Unit 1. In addition, data from a parametric carbon injection test (conducted January 2005) were analyzed. The results from these data analyses are currently under review by project team members. Once the results are reviewed, they will be reported in the next quarterly report. Results from the analysis of solid and liquid samples, and the third Ontario Hydro verification campaign are reported.

3.1 Long-Term Injection Test Results

Collection and Analysis of Solids Samples

Coal, ash, and FGD byproduct samples were collected during the long-term injection test and were analyzed. The FGD solids Hg concentrations and FGD slurry chemical analyses results are not yet available.

Table 3-1 shows the coal mercury and chloride values measured for selected samples.

Table 3-1. Coal Hg and Cl Values for Selected Samples from Long-Term Test

Coal Sample Date	Coal Hg (ug/g)	Coal Cl (mg Cl/kg)
11/3/2004	0.055	
11/14/2004	0.100	
11/17/2004	0.078	112
11/19/2004	0.068	
11/22/2004	0.037	
11/29/2004	0.090	
11/30/2004		119
12/5/2004	0.101	
12/6/2004	0.068	
12/9/2004	0.046	
12/10/2004		122

Table 3-2 shows the ash mercury and LOI contents for selected samples. A diagram of ESP is shown in Figure 3-13. The ESP is equipped for sampling from hoppers 2, 3, 6, and 7. A composite sample was taken of hoppers 2 and 3, with 50% of the ash coming from each hopper. Likewise, a composite sample was taken of hoppers 6 and 7.

In general the mercury concentration of Hoppers 6/7 was higher than Hopper 2/3. There does not appear to be a consistent trend in the relative LOI concentration between the two sets of hoppers.

On 12/1/04, separate samples were taken from each of the four hoppers. All four samples were analyzed to note differences in composition between hoppers 2 and 3 and between hoppers 6 and 7. The difference in mercury content between hoppers 2 and 3 is within the range of mercury concentrations measured throughout the test. A similar conclusion is drawn from the hoppers 6 and 7 samples on 12/1/04.

Table 3-2. Ash Hg and LOI for Selected Samples from Long-Term Test

	Hg (ug/g)		% LOI	
SAMPLE ID	Hopper 2/3	Hopper 6/7	Hopper 2/3	Hopper 6/7
11/15/2004	0.44	0.66	10.1	9.7
11/19/2004	0.57	0.57	13.5	12.1
11/29/2004	0.35	0.74	5.3	6.4
12/1/04, Hopper 2	0.26		6.1	
12/1/04, Hopper 3	0.36		9.9	
12/1/04, Hopper 6		0.53		8.8
12/1/04, Hopper 7		0.60		14.1
12/6/2004	0.43	0.70	11.2	14.2
12/10/2004	0.29		17.4	
12/13/2004	0.64	0.54	12.5	18.3

Table 3-3 shows the mercury concentrations of the FGD liquors sampled during the long-term test. The FGD liquor mercury concentration showed variability and ranged from 2.4 µg/L to 31 µg/L. The FGD liquor from baseline (no injection) testing had a concentration of 15 µg/L. Therefore, it does not appear that the mercury concentration of the liquor consistently, significantly increased during the long-term injection test.

Table 3-3. FGD Liquor Hg Concentrations for Selected Samples from Long-Term Test

FGD Slurry Sample Date	FGD Liquor Hg (ug/L)
11/14/2004	13.568
11/25/2004	10.438
11/26/2004	2.431
12/5/2004	23.529
12/10/2004	9.276
12/15/2004	31.237

3.2 January 2005 Parametric Tests

Sorbent injection tests were conducted on Unit 1 for three different activated carbons and one activated carbon/PRB ash blend. The testing began on January 17^{th} with a full day of baseline testing and continued with individual sorbent testing over the next four days. Results for the Unit 1 parametric tests using the Coarse HOK, Darco Hg-LH™, and Darco Hg™ activated carbons as well as a Darco Hg™-Miller (PRB) ash blend have been evaluated and are currently under review by project team members. The mercury removal results from these tests will be presented in the next quarterly report. A description of the parametric testing is included with this report.

Test Conditions and Modification to Test Plan

Field test conditions for the Unit 1 activated carbon parametric tests are summarized below in Table 3-4. All sampling activities were completed as planned. Baseline characterization of the Unit 1 system was conducted on Day 1; sorbent injection tests were conducted on Days 2 through 5.

The duration of each injection rate was approximately two hours since previous injection testing on Unit 1 indicated that two hours was sufficient time to reach a steady state flue gas mercury concentration. Because of the relatively short time necessary for flue gas mercury concentrations to reach steady state and the need to further observe the effects of carbon injection on ESP performance, testing of multiple carbon injection rates was possible on each day of sorbent testing.

Table 3-4. Field Test Conditions for the Unit 1 Baseline and ACI Parametric Tests

Date	Baseline, Full Load	Coarse HOK Carbon Injection, Full Load					Darco HgÔ-Miller Ash Blend, Full Load		
	Day 1	Day 2					Day 3		
	1/17/05	1/18/05					1/19/05		
Injection Time Period (EST)	N/A	10:35 – 12:35	12:35 – 14:27	14:27 – 16:27	16:27 – 17:50	17:50 – 18:15	10:23 – 12:23	12:23 – 14:40	14:40 – 16:40
Actual Injection Rate (lb/MMacf)	0	5.0	6.9	10.4	13.9	16.2	5.0	6.9	10.4
Actual Injection Rate (lb/hr)	0	143	200	300	400	467	143	200	300

Date	Darco Hg-LHÔ Carbon Injection, Full Load					Darco HgÔ Carbon Injection, Full Load	
	Day 4					Day 5	
	1/20/05					1/21/05	
Injection Time Period (EST)	10:20 – 12:35	12:40 – 15:15	15:15 – 16:11	16:11 – 18:30	18:30 – 20:00	10:55 – 12:55	12:55 – 18:30
Actual Injection Rate (lb/MMacf)	5.0	6.9	10.4	2.4	11.7	2.4	5.2
Actual Injection Rate (lb/hr)	143	200	300	70	337	70	150

Coal, Fly Ash, JBR FGD Byproducts, and Other Process Streams

Coal

Table 3-5 shows the analytical results for as-fired coal samples. Composite samples of the Unit 1 coal were collected once daily upstream of the coal pulverizers and were analyzed in triplicate for mercury; an average of the triplicate analyses is reported in the table. Ultimate/proximate and chlorine analyses were performed on selected samples, and these results are also shown.

Fly Ash

Table 3-6 shows the results for mercury and LOI analyses of the ESP fly ash samples. Composite fly ash samples were obtained during the baseline characterization and sorbent injection test periods. The samples were collected via the solids sampling method described in the long-term ACI portion of this report.

The carbon content of the ESP fly ashes, as measured by percent LOI, were very similar during the injection testing, but there was no ESP ash collected during the baseline to compare to the injection testing results. However, previous analysis has shown no apparent increase in the carbon content of the ESP fly ash during injection testing when compared to baseline tests.

Table 3-5. Unit 1 – Coal Analyses for Baseline and ACI Parametric Tests

Date	**1/17**	**1/18**	**1/19**	**1/20**	**1/21**
Sample Time (EST)	**17:00**	**10:33**	**n/a**	**14:30**	**10:00**
Test Condition [a]	**BL**	**HOK**	**Da-M**	**Da-LH**	**Da**
Proximate, wt % as received					
Moisture	8.75	6.49		5.47	
Ash	13.08	12.04		12.50	
Volatile Matter				32.12	
Fixed Carbon				49.91	
Ultimate, wt % as received					
Carbon				68.85	
Hydrogen				4.47	
Nitrogen				1.54	
Sulfur	1.07	1.39		1.47	
Oxygen				5.70	
Heating Value (Btu/lb, as received)	11790	12293		12330	
Mercury (μg/g, dry)	0.077	0.137	0.090	0.130	0.099
Mercury (lb/trillion Btu)	6.5	11.2		10.6	
Chlorine (mg/kg, dry)	290			272	

Table 3-6. Unit 1 – ESP Fly Ash Analyses for Baseline Characterization and Sorbent Injection Tests

Date	**Time (EST)**	**Sample Type**	**Test Condition**	**Injection Rate (lb/MMacf)**	**Mercury (mg/g)**	**LOI (%)**
1/18	~12:30	ESP Ash	Coarse HOK	5.0	0.64	13.9
1/19	~12:30	ESP Ash	Darco Hg™-Miller	5.0	0.54	12.2
1/20	~12:30	ESP Ash	Darco Hg™-LH	5.0	0.62	12.0
1/21	~12:30	ESP Ash	Darco Hg™	2.4	0.77	11.6

3.3 Ontario Hydro Results from Third Verification Campaign

The third Ontario Hydro campaign for the Yates ACI project was conducted December 1-2, 2004, in the middle of the long-term carbon injection test. Ontario Hydro measurements were made at the ESP outlet and the stack. Ontario Hydro measurements were not made at the air heater inlet, because of cyclonic flow problems that made isokinetic sampling impossible and a reactive ash that adsorbed mercury in previous Ontario Hydro testing (as discussed for Verification #1, conducted in February 2004).

An unexpected boiler tuning was carried out during the Ontario Hydro campaign, so load varied during the runs. As shown in previous process data, the unit load has a direct and immediate impact on the flue gas mercury concentration. Variations in mercury concentration across the sample time impact the Ontario Hydro and SCEM data in different ways. For the Ontario Hydro method, there are separate impingers to collect the elemental and oxidized mercury fractions. The flue gas mercury concentrations derived from these impinger catches represent an average of the entire time period of sampling. In contrast, the SCEM alternates between total and elemental mercury concentration measurements. For these Ontario Hydro verification runs, which typically lasted 2 hours per run, total mercury concentration was measured continuously for 1 to 1.5 hours in the period, then elemental mercury concentration was measured from 0.5 to 1 hour.

Because of the alternating between total and elemental mercury measurements, it was often the case that the SCEM elemental mercury measurements were obtained during one load and the SCEM total mercury measurements were obtained at a different load. This situation led to incongruous disparities between the total and elemental mercury concentrations measured by the SCEM. For example in Run 1 at the stack, the total mercury, which was measured at a low load, was measured to be a lower concentration than the elemental mercury, which was measured at a higher load.

The average total and elemental mercury concentrations measured by the SCEM during the course of each two-hour Ontario Hydro run are reported in Table 3-7. The average of the three runs is not reported, because process conditions varied too much from run to run for an average to be meaningful. Instead, run-by-run comparisons were made between the Ontario Hydro and SCEM data.

Both SCEM and Ontario Hydro show the same trends in variation of total mercury concentration from run to run at both locations; however, the relative difference between the values for any given run ranges from 13 to 55 %. The oxidized mercury concentrations measured by the two methods showed more agreement, with very good agreement at the scrubber outlet where little oxidized mercury is present. At the ESP outlet, the percent oxidized mercury matched well between SCEM and Ontario Hydro for runs 1 and 2. For run 3 at the ESP outlet, the SCEM measured higher oxidation than the Ontario Hydro (load ramping is not the reason, as load was at its highest when elemental mercury was measured).

For runs 2 and 3 there is good agreement between the Ontario Hydro and SCEM for the total mercury removal across the scrubber (20 to 30%). In run 1, the SCEM indicates 47% removal of total mercury, while the Ontario Hydro value indicates only 9%. Neither of these values is within the range of removals measured in runs 2 and 3.

Both SCEM and Ontario Hydro indicate possibly a small amount of re-emission of elemental mercury across the JBR scrubber. However, at the low concentrations being measured, the differences in elemental mercury concentration across the scrubber are within the measurement uncertainty (especially for Ontario Hydro).

The ESP outlet and stack total mercury concentrations were converted to lb Hg/trillion Btu basis. For the Ontario Hydro method, the average outlet concentrations were 1.90 lb/trillion Btu at the ESP outlet and 1.55 lb/trillion Btu at the stack. For the SCEM, the average outlet concentrations were 1.41 lb/trillion Btu at the ESP outlet and 0.91 lb/trillion Btu at the stack.

Table 3-7. Unit 1 - Comparison of Average SCEM and Ontario Hydro Mercury Measurements During Long-term Sorbent Injection; December 2004

	Run No.	Sampling Period (CST)	Vapor Phase Hg Concentration			
			Elemental	Oxidized	Percent Oxidized	Total
ESP Outlet, μg/Nm^3						
SCEM	1	12/1/04 11:30-13:30	1.39	1.09	44	2.48
OH	1		1.99	1.02	34	3.01
SCEM	2	12/2/04 7:05-9:06	0.53	0.88	63	1.41
OH	2		1.15	1.82	61	2.97
SCEM	3	12/2/04 11:20-13:30	1.51	2.02	57	3.53
OH	3		2.68	1.40	34	4.08
Stack μg/Nm^3						
SCEM	1	12/1/04 11:30-13:30	1.32	-0.31*	0	1.01*
OH	1		2.41	<0.33	<12	2.74
SCEM	2	12/2/04 7:05-9:06	0.70	0.40	36	1.10
OH	2		2.13	<0.30	<12	2.43
SCEM	3	12/2/04 11:20-13:30	2.08	0.30	13	2.38
OH	3		2.76	0.26	9	3.02
Removal*, %**						
SCEM	1	12/1/04 11:30-13:30	5	100	NA	47
OH	1		-21	68	NA	9
SCEM	2	12/2/04 7:05-9:06	-32	55	NA	22
OH	2		-85	84	NA	18
SCEM	3	12/2/04 11:20-13:30	-38	85	NA	33
OH	3		-3	81	NA	26

Note: All data normalized to 3% oxygen. Oxidized mercury for SCEM calculated as difference between measured total and elemental mercury. Total mercury for OH calculated as sum of measured elemental and oxidized mercury. Because of changing load conditions from run to run, an average of the three runs is not an appropriate value to evaluate.

*Total mercury concentration measured by SCEM at Stack for Run 3 was lower than elemental mercury concentration because of load change in middle of run, hence the negative value for oxidized mercury. The elemental mercury value was used in computation of total mercury removal across scrubber.

4.0 Conclusions

This document summarizes progress on Cooperative Agreement DE-FC26-03NT41987, "Sorbent Injection for Small ESP Mercury Control in Low Sulfur Eastern Bituminous Coal Flue Gas," during the time-period January 1, 2004 through March 31, 2005. The objective of this project is to demonstrate the ability of various activated carbon sorbents to remove mercury from coal-combustion flue gas across full-scale units configured with small ESPs. The project is funded by the U.S. DOE National Energy Technology Laboratory under this Cooperative Agreement. EPRI, Southern Company, and Georgia Power are project co-funders. URS Group is the prime contractor.

Several carbon-based sorbent materials were injected upstream of low-SCA ESPs at Georgia Power's Plant Yates Unit 1 and Unit 2. Both Unit 1 and Unit 2 fire a low sulfur bituminous coal. Unit 1 is equipped with a cold-side ESP upstream of a JBR wet FGD system for SO_2 control. Unit 2 is not equipped with downstream SO_2 controls; however, a dual flue gas conditioning system is used to enhance ESP performance.

During this reporting period, analysis continued on the data collected during the long-term injection test on Unit 1. The carbon selected for the long-term injection test was RWE Rheinbraun's Super HOK carbon. The majority of the test was conducted at carbon injection rates between 4 and 10 lb/Macf. Mercury removal across the ESP ranged from 50 to 91% over the test period, with the majority of the data concentrated between 60 and 85%. The mercury removal across the ESP/JBR scrubber system ranged from 70 to 94%. In contrast, baseline (no injection) mercury removals were 50% across the ESP and 80% across the system.

Detailed analyses were conducted to relate the mercury removal performance to the unit load operating condition and to compare results to the original parametric tests. A thorough evaluation of ESP arcing data was conducted. A second set of parametric injection tests was conducted during this reporting period. Alternative sorbents, such as a brominated carbon and ash/carbon mixture were tested. Results will be provided next quarter.

5.0 Activities Scheduled for Next Quarter

The next quarterly reporting period covers the period April 1, 2005 through June 30, 2005. The primary activities planned for this period include completion of the economic analysis and the Unit 1 and Unit 2 site reports.

6.0 References

None for this document.